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VISIBLE AREA MAPPING

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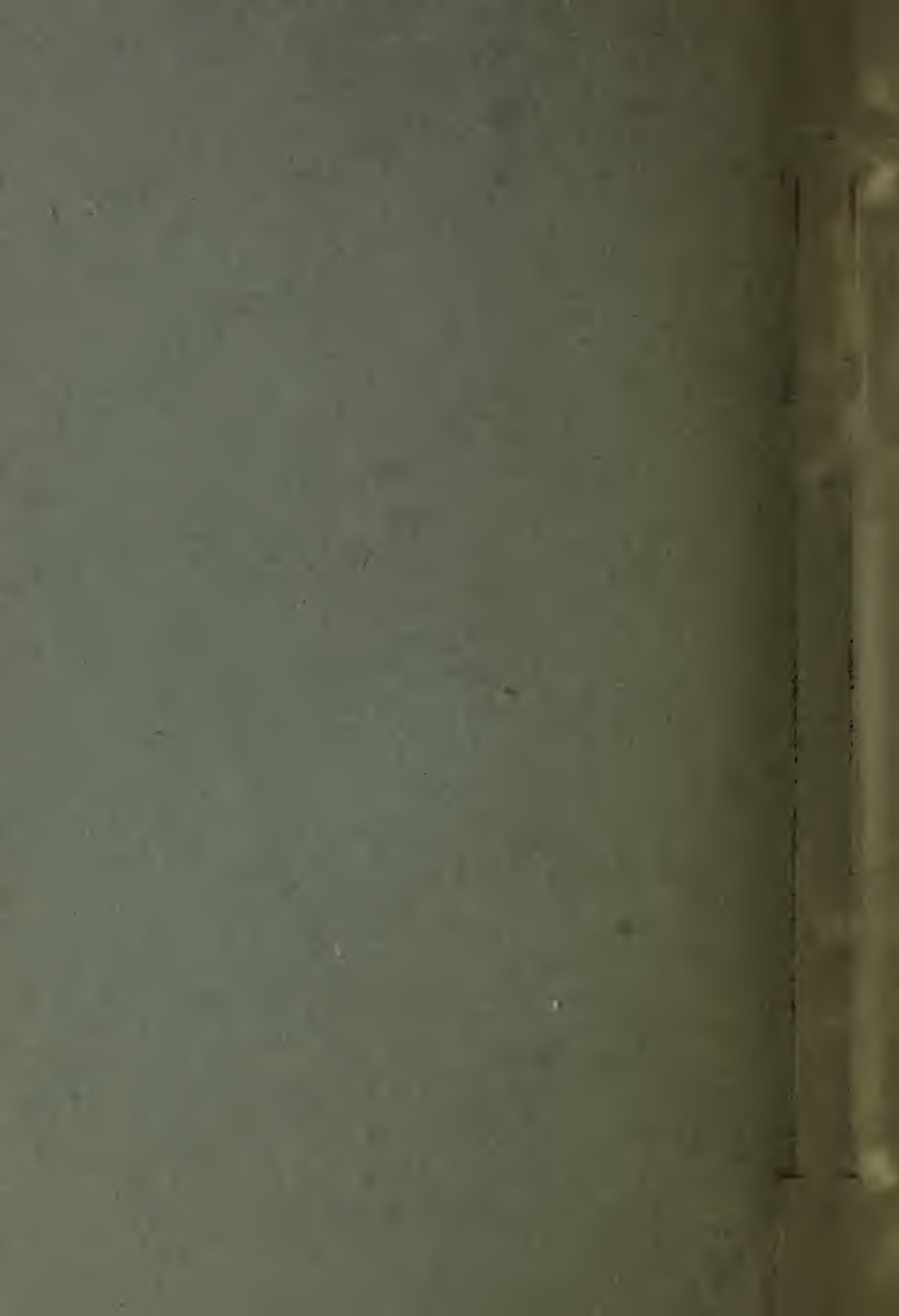
C. A. Abell

and

R. M. Beeman

Appalachian Forest Experiment Station

October, 1936.



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INTRODUCTION

To locate a fire detection station properly may appear a simple matter - yet upon further examination it is evident that each point is part of a coordinated system and the location of one station in a primary network affects the correct location of other stations. Consequently, it becomes desirable to plan as early as possible the entire detection system needed for covering any forest unit, even for those units with some lookout stations already established. Through such detection planning, the most efficient arrangement of lookout stations can be economically developed.

In detection planning the first need is for basic data in the form of accurate visible area maps from present, prospective, and possible lookout points. Experience and tests have shown that a lookout can be expected to render consistently dependable service for only those portions of the country that he sees directly. The detection service he may be able to give in blind and in what are sometimes called "indirectly visible" areas is too variable to be counted upon. The amount and location of area directly visible from different lookout points is a sound and workable basis for comparing the values of those points for detection purposes.

MEMORANDUM

TO : THE PRESIDENT
FROM : THE SECRETARY OF THE ARMY
SUBJECT: [Illegible]
[Illegible text follows]

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Visible area maps furnish this information. The aim of this paper is to provide workable instructions for preparing such maps. Forthcoming articles will deal with subsequent steps in detection planning.

METHODS OF VISIBLE AREA MAPPING

A visible area map is a base map, preferably topographic, upon which is delineated the areas which can be directly seen from a designated point on a clear day. Directly visible area is that where the ground itself or the vegetation upon it is in full view.

Visible area maps have been prepared by the following methods:

- (1) Field sketching (which requires occupation of the prospective lookout point while the visible areas are mapped by engineering methods)
- (2) Office profiling (an office procedure whereby visible areas are mapped entirely from information shown on the contour map)
- (3) Office mapping from photographs taken with the Osborne photo-recording transit.
- (4) Office mapping by the use of lights on a relief model.

The third method is not considered generally applicable in the Southern Appa-

lachians because vegetation interferes with photographing from many prospective points. Days clear enough for photographing are very infrequent in comparison with those sufficiently clear for field sketching. Also, it usually takes one day to photograph from a point and another day to map from the photographs, whereas a skilled mapper can go to a point and complete the field sketch map in one day.

The cost of the fourth method bars it from serious consideration in most cases.

COMPARISON OF FIELD SKETCHING AND PROFILING METHODS

Field sketching, if practicable, is usually more accurate and dependable and is, therefore, decidedly preferable to profiling. The two methods require about the same time - two days per point for a beginner, usually decreasing to one day per point after two weeks' experience.

If the contour map is on a small scale, or inaccurate, or if the point is not a distinct peak, profiling decreases in reliability. On the other hand, field sketching permits discovery of and partial correction for error in the base maps, and is not affected materially by the shape of the peak from which visible areas are being mapped. A series of visible area maps made by an experienced man from a distinct peak surrounded by topography more complex than average, in-

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licated that the profile map was 65% accurate, whereas the field sketches averaged 86% correct. In this comparison, the base maps used were U.S.G.S. topographic quadrangle sheets, scale about 2 miles to one inch. Had maps on a scale of one inch equal one mile been used, profiling and also field sketching would probably have given still more accurate results.

SELECTION OF POINTS TO BE MAPPED

In planning the work for any given unit, the first step should be to get a bird's-eye view of the situation by preparing an office base map composed of topographic sheets with the boundaries of the area for which the detection plan is desired outlined in some conspicuous color. The first points from which to map visible areas are the established lookouts, primary and secondary; next are those which the ranger may suggest as possibilities. While field sketching, at each point occupied, the mapper can scrutinize nearby peaks, noting both their possible value for detection purposes and the feasibility of sketching from them. Information on the latter question can often be obtained from the ranger or from local residents. When the visible area map has been prepared for a selected point, a pin may be inserted at the corresponding location on the office map. As the work progresses, occasional study of the visible area maps constructed and the office base maps will indicate blind areas and possible points from which to see into them.

Timbered peaks, providing labor is available and the timber of low value, should

be cleared to permit field sketching. If clearing is undesirable, a temporary wooden tower may permit mapping. Only as a last resort should office profiling be used. If, however, this becomes necessary, and the final detection plan includes a profiled map, that point should then be mapped in the field, since gross discrepancies between profile and field sketch map may necessitate revision of the detection plan.

PREPARATION OF BASE MAPS

A clean contour sheet for each point to be mapped is necessary in either field sketching or profiling. The scale of about two miles to the inch and a contour interval of 100 feet, which are U.S.G.S. standards, were found suitable for field sketching in the Southern Appalachian Mountains.

For Eastern forests in general, the radius of the circle, within which directly visible areas are mapped, should be not less than 10 miles. Preliminary haze meter records in the Southern Appalachians indicate that the average effective radius for primary lookouts to be used in detection planning will be less than 10 miles. However, once at a point, the field mapper can generally map to a 10 mile radius in one day. Mapping to a lesser radius will not increase daily production, and all information obtained to a 10 mile radius is useful in detection planning. Briefly, areas within different radii can be weighted according

to the average percent of days the lookout can see a standard smoke that far, according to haze meter records.

Unless the point from which the map is to be made is located near the center of a quadrangle, two to four portions of quadrangles must be cemented together. Rubber cement should be spread on the margin of one piece only, the adjacent portion put approximately in place, and then slid into the most satisfactory fit. After the joined edges are dry, the surplus cement should be rubbed off, the forest boundaries outlined in brown ink, and the holes punched for atlas insertion.

Due to the possibility of inaccuracies of the U.S.G.S. quadrangles, the point from which mapping is to be done may be located more or less incorrectly. If its precise latitude and longitude have been determined by the U. S. Coast and Geodetic Survey, or by the U.S.F.S. surveys, this accurate location may be plotted on the map and the ten mile circle drawn in black ink. Otherwise the point on the map is temporarily considered as correctly located and the circle tentatively drawn in pencil. A closer location may be obtained by the 3-point method when the point is occupied, as described below under "Sketching Technique."

In profiling, unless the point has been triangulated after the map was made, its location will obviously have to be accepted as mapped, and the possibility of incorrect location considered in evaluation of the resultant profile map.

1. The first part of the report is a general
introduction to the subject of the study.

2. The second part of the report is a detailed
description of the methods used in the study.

3. The third part of the report is a discussion
of the results of the study.

4. The fourth part of the report is a conclusion
based on the results of the study.

5. The fifth part of the report is a list of
references.

6. The sixth part of the report is a list of
figures.

7. The seventh part of the report is a list of
tables.

8. The eighth part of the report is a list of
appendices.

9. The ninth part of the report is a list of
acknowledgments.

Materials Needed for Preparation of Base Maps

For preparation and care of base maps, the following equipment is needed:

1. U.S.G.S. quadrangles, (retail price 10¢ each, or other contour maps)
2. Scissors
3. Large drawing compass with pen attachment
4. Black India ink
5. Brown waterproof ink and medium sized pen
6. Paper cement (Best-Test White Rubber Paper Cement, sold in a pint can by Union Rubber & Asbestos Co., Trenton, N. J., price 50¢, recommended)
7. Gummed reinforcements
8. Loose-leaf Atlas binder, approx. 18 in. by 21 in. (for map scale 2 miles to inch)

PROFILING TECHNIQUE

Purpose Served by Profiling

In addition to its use as a method for mapping visible areas, profiling provides indispensable training for the prospective field sketcher. Three or four days occupied in profiling will instill a conception of the shapes of visible areas which may be expected to hasten considerably acquirement of proficiency in field sketching.

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Equipment Needed

The following equipment is needed for profiling:

1. Profiling board
2. Thumb tacks
3. 4-H Pencil and eraser
4. No. 4 Scripto pencil, with red lead No.132
5. Celluloid protractor
6. Black India ink and Croquill pen

If a considerable amount of profiling is to be done, a Bausch and Lomb Adjustable Standard Magnifier, which retails at \$12, will aid by eliminating eye strain and increasing speed.

The "Profiling Board"

The construction of visible area maps in the office may be greatly simplified by the use of a "profiling board"*, which is easy to make and is an excellent labor saving device. It consists of a piece of transparent celluloid, rectangular except for a small projecting tab in the upper left hand corner, the whole backed by cross section paper 10 squares to the inch. (See Fig. 1) The size of the celluloid depends on the scale of the map, the radius of profiling, and the range of elevations. With a map scale of 1 inch equals 2 miles, 10 mile radius of mapping and elevations ranging from 1500 to 6000 feet, the cross section paper and celluloid should be 10 inches long and 6 inches wide. The cross section

* Devised by the California Forest and Range Experiment Station.

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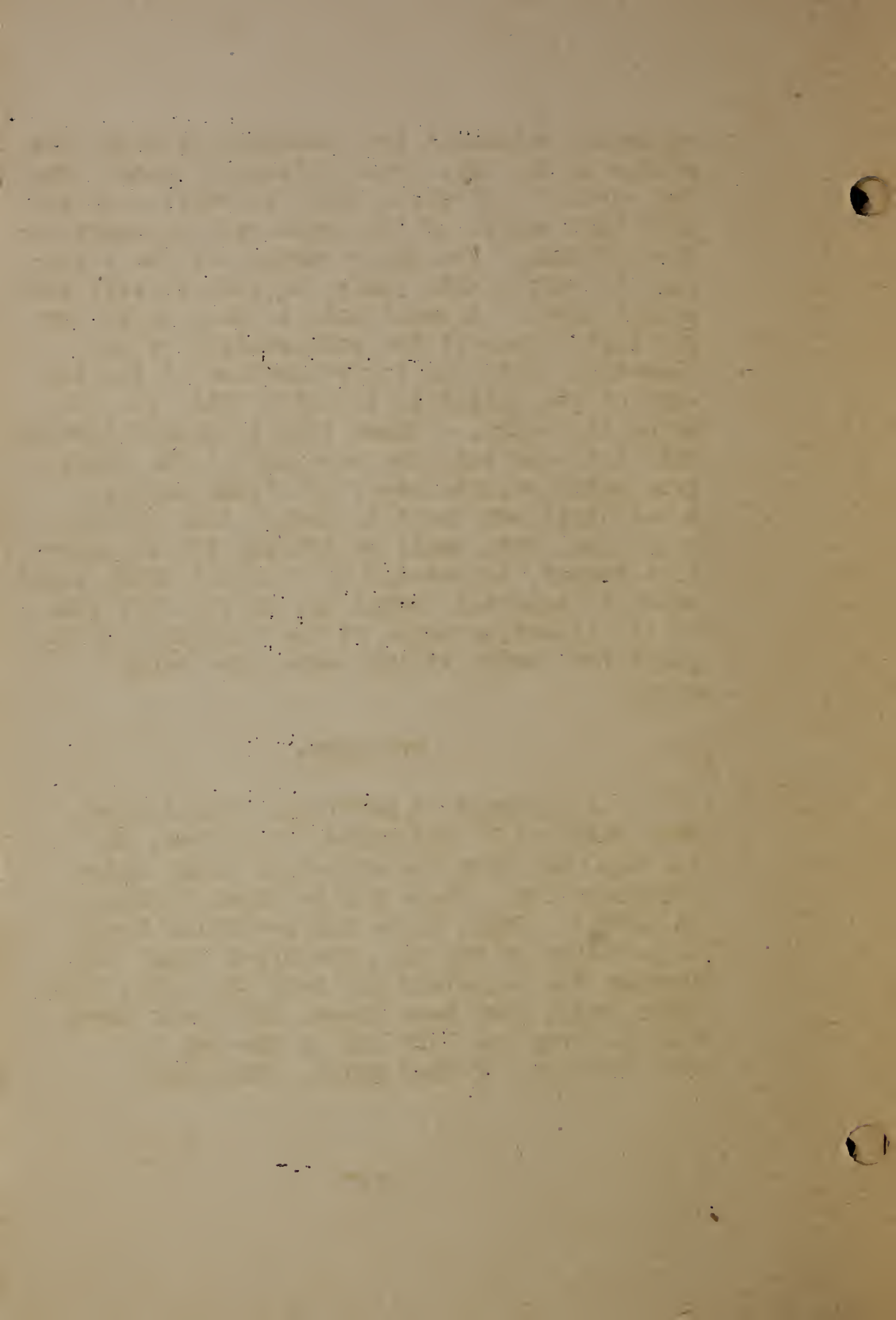
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paper and celluloid are conveniently bound together on the edges with cellulose scotch tape. The vertical elevation scale is written up the left hand margin of the cross section paper before binding. The upper surface of the celluloid is buffed with pumice so that it will take pencil marks. A small hole is made in the upper left corner at the intersection of the elevation scale and the projection of the top edge of the celluloid (Point H, Fig. 1). In using the board, a thumb tack is pushed through this hole and into the base map at the point from which visible areas are being mapped. A celluloid arm about 10 inches long and one inch wide, with small protruding tab in upper left corner, is pivoted on a second thumb tack which is inserted, point up, on the left edge of the elevation scale at the elevation of the point from which visible areas are being mapped.

Procedure

A beginner at profiling should first draw radii at 5° intervals, or closer, on the base map from the detection point under consideration. These may be drawn lightly in pencil. Then, place the profiling board in position on the map, the upper thumb tack through the celluloid and into the point from which radii have been drawn, the lower thumb tack holding the left end of the arm at the elevation of that point. The upper

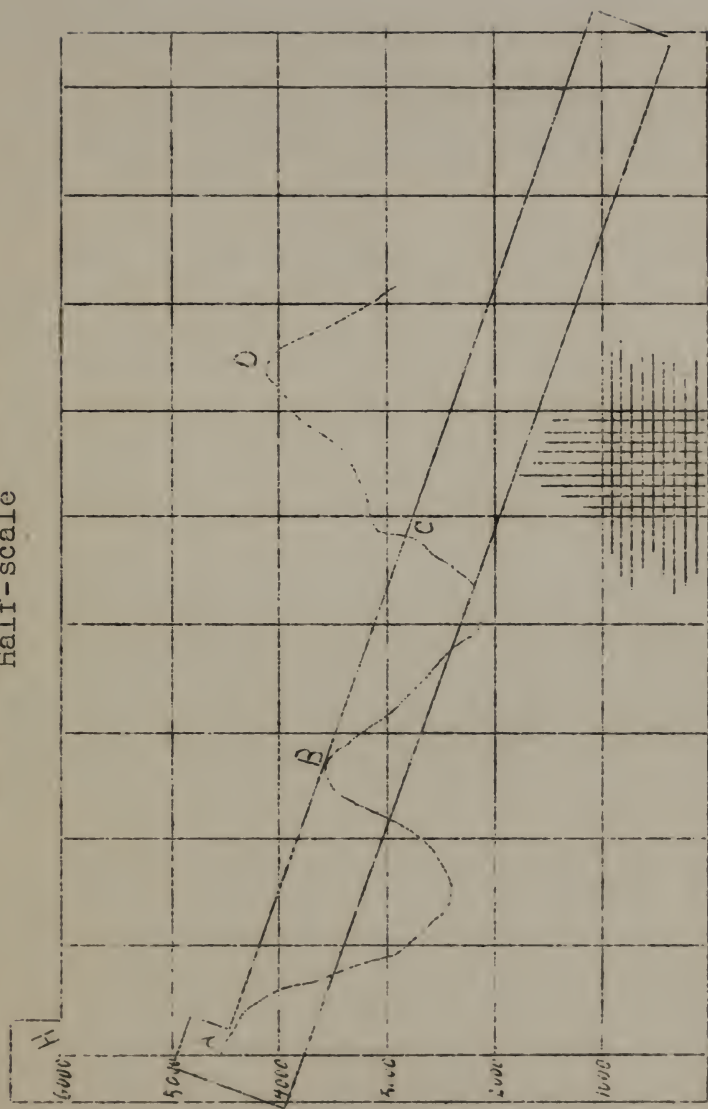


edge of the profiling board is placed along any one radius and mapping may proceed.

The beginner will find it advantageous to plot complete profiles along several radii. This is simply done by plotting on the celluloid sheet the elevation of points along the radius directly beneath where they occur on the topographic map. The points so located are then connected by a continuous line to produce a profile such as shown on Fig. 1. In the case illustrated, that section of the radius vertically above the section of the profile from B to C would not be seen, while that vertically above C to D would be visible. That section of the radius above C to D should be lined with red pencil to indicate that it is directly visible.

After all radii are profiled, the map will show an assortment of red segments of radii representing visible sections along those lines of sight. The ends of adjacent red segments must now be connected, bearing the following considerations in mind. The far boundary of a visible area will usually follow a ridge top. The near boundary will bend in and out as a result of two independent factors: first, the vertical and horizontal variations in the obstructing ridge or ridges; second, the topography at said near boundary. A rise in the obstructing ridge, or a swing of the obstructing ridge back away from the lookout point, will push the boundary of the next visible area back. Likewise, a dip in the topography, such as a drainage, at that boundary, will push it back. Where the

Figure 1.
CALIFORNIA PROFILING BOARD
Half-scale



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trend of a visible area boundary between radii is doubtful, a few intermediate points between radii should be plotted. It is particularly desirable that the beginner plot many of these intermediate points to form a sound conception of visible area shapes. After boundaries have been defined, directly visible areas should be shown in solid color.

The tab on the upper left hand corner of the profiling board, covers up the topography close to the lookout point. Therefore, before placing the board in position, the closest obstructing ridges should be picked out and accentuated with a pencil line. Plotting should start from these closest obstructions and proceed outward.

The above profiling method, using 5° radii, will consume about two days per map. After considerable experience in the field, a mapper will be able to dispense with mathematically spaced radii and use only controlling points. One day per map will then suffice.

After a practice period with complete profiles, time-saving short-cuts will be obvious. For example, in a case such as shown in Fig. 1, the profile from D towards the point of origin can be plotted from right to left merely carrying it far enough to intersect the line of sight ABC.

After considerable experience, the following procedure may be employed: Beginning at the center of the circle, find the

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first ridge top which lies more or less at right angles to the radius. Note its elevation, run vertically down to that same elevation on the profile board and swing the arm so its upper edge passes through that point. Shift pencil out along radius to estimated limit of blind area in back of the first ridge and glance vertically down to the arm. If the arm reading is higher than contour elevation at pencil position, shift pencil to right; if the arm reading is lower, shift pencil to left; if they coincide, mark the point on the radius then and line the radius with red pencil (to indicate a segment of visible radius) from that point away from the center to the next ridge top. Readjust the arm to pass through elevation of the top of this next ridge and proceed as before. In the same manner, determine the limits of visibility caused by other ridges along that radius.

FIELD SKETCHING TECHNIQUE

Time Required

After three or four days of profiling, the mapper will have acquired a conception of visible area shapes and be prepared to start field sketching. Even with such preliminary practice, a beginner will at first probably consume two to three days per field sketch. Factors other than experience affecting the rate of mapping are accessibility of peak, amount of timber obscuring view, gross amount and complexity of visible area, atmospheric conditions, and accuracy of the base map. An experienced man should

produce a completed field sketch in from three to eight hours.

Equipment Needed

For field sketching in the Appalachians, the following equipment was found necessary:

1. Previously prepared base maps
2. 18 x 24-inch plane table with canvas case
3. Light tripod
4. Topographic Abney Level
5. Engineer's slide rule
6. 10-inch open-sight alidade with scale on edge
7. 8-inch celluloid protractor
8. U. S. Engineer's Compass
9. Dark glasses
10. 4-H pencils
11. No. 4 Scripto pencil with red lead No.132
12. Erasers
13. Emery paper pad
14. Tracing paper
15. Thumb tacks

Written instructions may come in handy during the first few days. Small equipment and lunch can be carried satisfactorily in a leather brief case or ranger carrying case having compartments for pencils, paper, etc.

Field Procedure

The field procedure is as follows:

1. Prior to day of mapping, prepare contour base map, and determine best route to the peak.

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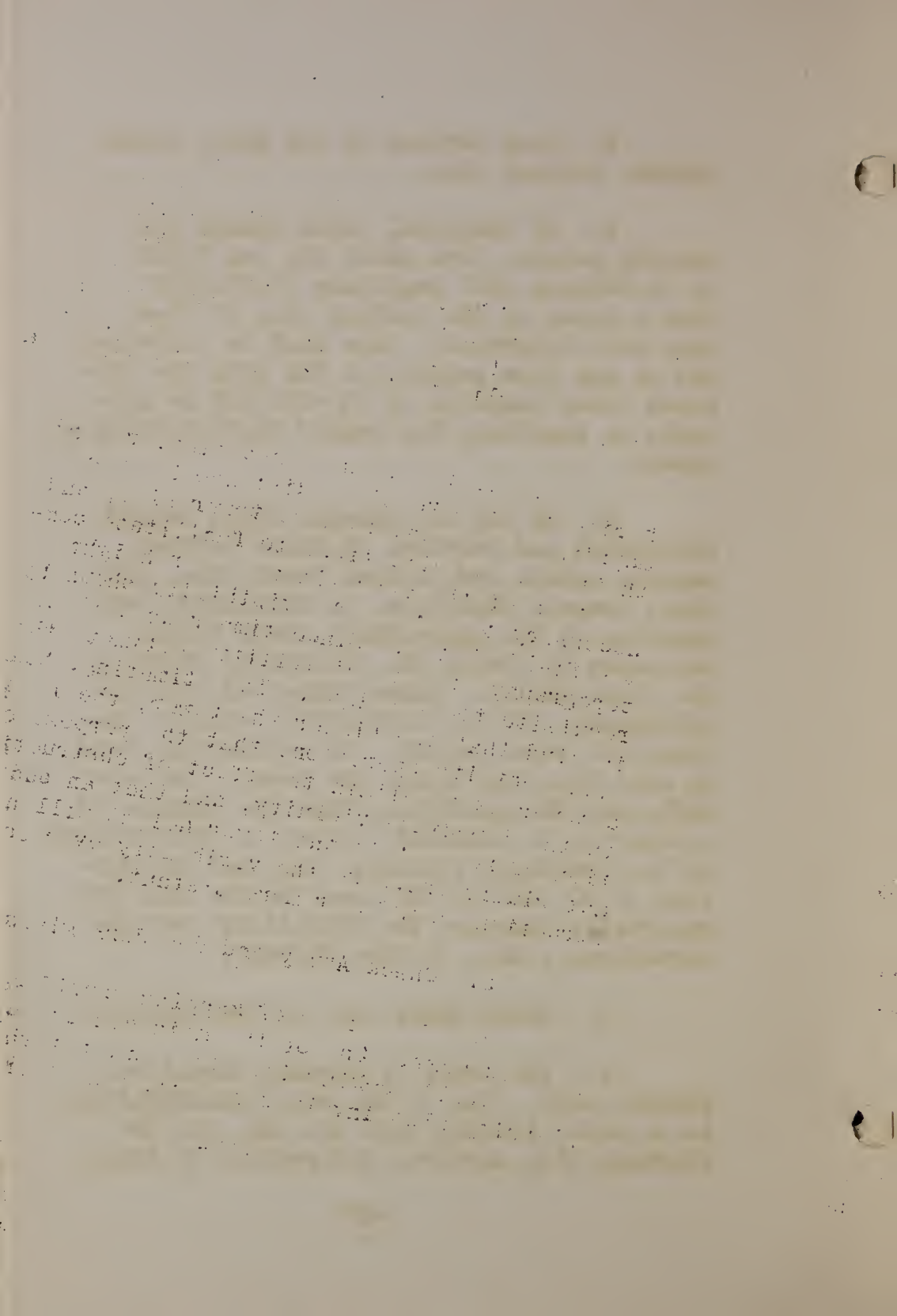
2. Upon arrival at the peak, select logical lookout site.

3. If timbered, scout around for mapping points, from which the sum total of visibility will duplicate visibility from a tower on the lookout site if view were not obstructed. Care must be exercised not to map from points too far from the proposed tower location or it will not be possible to duplicate the mapped visibility by a tower.

4. If top is somewhat flat, record horizontal and vertical distance between mapping points and lookout tower site, and their compass direction, to facilitate computation of the approximate tower height necessary to obtain the visibility shown by the field sketch. Since timber as well as topography affects visibility, estimate the requisite tower height. In estimating, bear in mind that the higher the tower, the less efficient its operation, that the purpose of a tower is to eliminate effect of obstructions in the immediate vicinity, and that an addition of 20 feet to the tower height will not materially increase the visibility over obstructions a mile or more distant.

5. Check Abney and don dark glasses.

6. The order of mapping should be planned next. One of the main considerations is to avoid looking into the sun, but the planning also involves observation of inten-



sity and direction of haze, smoke, fog, etc., and speculation upon changes therein during the day. Usually it hazes in the west in the mid-afternoon; therefore, other things being equal, the western sector should be mapped by noon. If the afternoon promises to be generally hazy, any portion of the area of lesser importance may be left until the last, for example, that outside the unit boundary, or a sector the visibility of which is not affected by obstructions close to the peak. The latter, especially if the base map scale is one inch to the mile or larger, may then be profiled in the office with considerable assurance of requisite accuracy. If the mapper becomes pressed for time, gentle topography near the outer limits of the map may be profiled later in the office with fair accuracy - provided all controlling points resulting from close obstructions are indicated prior to leaving the peak.

7. Set up plane table at selected point. Level with Abney bubble.

8. Orient the plane table.

The method of orientation will vary with the amount of information at hand. If the point being occupied has been located by triangulation and some other mountains are visible which you know have been located by triangulation, select one of them 5 miles or more away and orient on it. Push a thumb tack partially in at the point of observation, lay the alidade with its edge against the shank

and passing through the known triangulated point on the map. Turn the plane table top until alidade sights line up with that selected mountain top, then clamp the plane table top.

If the only precise location you are sure of is that of the observation point, orient on the most important peak in the sector being mapped. The chances are that it also has been triangulated. Thus, during the course of the day, the board may be oriented successively on several points, as mapping proceeds from one sector to another.

If the exact location of the occupied point on the map is not known, select at least three prominent peaks which are distinct in the field and on the contour maps. Lay a piece of tracing paper on the plane table, stick a pin near one edge, and by use of the alidade draw lines from the pin towards each of the 3 peaks. Then loosen the tracing paper and shift it around until each of the 3 lines passes through its respective peak as indicated on the map. The point being occupied should then lie at the intersection of the 3 lines. Its location can be pricked through onto the map with a pin. Check this location by sighting with the alidade on other points. When the location of the observation point has been identified on the map, orient as above on the most prominent peak in the sector being mapped. Orientation points selected should be distinct and at least five miles away.

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9. Mapping: The map produced will show directly visible area in solid color, and the blind or unseen area will be left blank.

Glancing from map to country, identify major features of topography. Then with little or no use of Abney and alidade, sketch in visibility boundaries within a mile or so, on a fairly large sector - perhaps half of a full circle - and color the visible area red. This will often involve modification of the contour map, as only slight errors in it will appreciably affect mapping of visibility close to the observation point. However, the contour map should be altered only when obviously incorrect, since modifications in themselves are subject to error. In general, mapping should progress from the center of the circle outward, and be completed in one sector before moving to another.

In mountainous territory, most of the directly visible area will be on the upper slopes facing towards the observer. The boundary of such a visible area is composed of four portions: the left, the right, the near, the far - as seen by the observer. The right and left extremities can be determined by sighting them through the alidade, and drawing short lines across the ridge top itself. The far boundary will be a line along the ridge top (unless the ridge is quite close to, and much lower than, the observer, in which case the opposite side

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of the ridge may also be visible). The near boundary will be a line along the near face of the ridge and, as profiling practice demonstrates, will bend with variations in topography of both the ridge face itself and the top of the obstructing ridge. This lower limit of visibility can be accurately determined by use of the Abney level and slide rule, as explained below.

Select a controlling point (lowest, highest) along this near boundary and obtain Abney reading (percent) on it. Place Abney reading on first cycle of "A" scale of slide rule; place opposite it (divide by) the factor .1894 on "B" scale, which disposes of the relationship - elevation in feet: distance in miles. Move glass runner along "B" scale to approximate distance in miles to the point in question. Directly above, on the "A" scale, read the difference in elevation (usually in hundreds of feet) between observer and point in question. These two figures - distance and difference in elevation - probably do not fit the ground. Move the runner back and forth until two values are found that do. Slide rule manipulation does not give the actual elevation of the point at which the Abney shot has been taken, but rather the difference between its elevation and that of the observer. A mental subtraction must be made to obtain the actual elevation of the point sighted. If the point sighted upon is higher than the observer, the difference in elevation should, of course, be added, rather than subtracted.

Repeat this process for several other controlling points along the near boundary of the visible area, and mark them with pencil. Connect the controlling points, checking the boundary location by any recognizable cultural features also shown on the map, such as roads. Color in red the completed visible area.

Continue thus for the entire area within the 10 mile circle. The face of a ridge which lies at about right angles to observer's line of sight, as that described above, is easiest to map. However, the same principles will apply for other conditions. Where the observer's line of sight is lengthwise of a ridge, portions of the two faces of the ridge will be blind, due to spur ridges and draws. Usually any ridge, high or low, will hide some country - often all of its opposite face, the drainage at the bottom of the slope, and partway up the slope beyond the drainage. Sometimes, however, the ridge may be so gently sloping near the crest that the observer can see down the far side until the slope becomes steeper. Occasionally, although the ridge crest itself shuts off visibility, the lower slope beyond may be so long and gentle that the observer can see the lower end of it and the drainage. Where a ridge obscures the near portion of a comparatively flat plain, Abney readings are taken as usual, on the near extremity of the visible area. Since, however, the distance to that near extremity may be difficult to estimate but its eleva-

tion approximated fairly accurately, the slide rule procedure may be reversed. After Abney reading has been divided by .1894, runner may set on "A" scale at the difference in elevation between observer and the general plain level, and the distance from observer read on "B" scale directly below.

The contour map may be in error, but in doubtful cases do not jump too hastily to conclusions. Remember that the men who made the maps were skilled topographers. If an alidade determination appears wrong, check it with the Abney; if an Abney shot seems incorrect, check it by cultural features. Abney shots to distant points should be checked and estimated to nearest tenth of a per cent, since a slight difference in reading makes considerable difference in elevation over several miles. Constant exercise of judgment is essential. As experience and skill increase, fewer Abney shots will be needed. However, each day's mapping should be started with copious use of instruments; then, as the eye becomes adjusted to the terrain, more reliance may be placed upon judgment.

10. Before leaving the peak, note as much information as time will permit on conditions affecting development for look-out purposes: distance from road, trail, telephone line, and dependable water supply; best present approach; amount of timber to be felled; name and location of owner; proximity of smoke or fog sources.

11. As soon as possible thereafter, visible area boundaries should be gone over with croquill pen and black India ink. On margin of map should also be printed data on the location of the several mapping setups in relation to the highest point, initials of mapper, date, and name of peak. If the point has not already been named by the U. S. Geographic Board, a name approved by the Ranger may be used. A common practice, generally acceptable, is to name the point for an old settler living in the vicinity.

These instructions are not considered as complete. Comments, criticisms, and additions are earnestly solicited from field men in order that future practice may be improved.



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F7625V
AUTHOR. [Abel]
TITLE. [isibl]

DEC 7 1938
FEB 14 1938
AUG 22 1938
AUG 1

